EFFECTS OF DIFFERENT LEVELS OF EM BOKASHI FERTILIZER ON YIELD COMPONENTS AND YIELDS OF *HELIANTHUS ANNUUS* L. (SUNFLOWER)

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Abstract

Sunflower (*Helianthus annuus* L.) is an important oilseed crop, but achieving optimal yields requires effective soil management practices. The use of EM bokashi, a fermented organic matter enriched with effective microorganisms, is being explored as a sustainable approach to enhance crop productivity. The study was carried out the effects of different levels of EM bokashi fertilizer on the yield components and overall yields of *Helianthus annuus* L. cv. (sunflower) under field condition. The experiment was carried out using Randomized Completely Block Design (RCBD) with replicated twice. The different levels of EM bokashi fertilizer (0, 1, 2, 3 ton acre^{-1}) were employed in this experiment. In the result, the 3 tons acre^{-1} of EM bokashi significantly improved several yield components, the tallest plant height (67.56 cm), the maximum number of leaves (22.80) and largest single leaf area (94.60), head diameters (12.57 cm plant^{-1}), 100 seeds weight (6.73 g plant^{-1}), and total seed weight (46.32 g plant^{-1}). Consequently, the overall seed yields of sunflower were increased (1.59 tons acre^{-1} and 33.39 baskets acre^{-1}) compared to control. The result indicated that 3 tons acre^{-1} of EM bokashi can be beneficial soil amendment for enhancing sunflower yield components and overall productivity, offering a sustainable alternative for improving crop yields.

Keywords: EM bokashi, yield components and yields

Introduction

Sunflower, *Helianthus annuus* L. belongs to family Asteraceae and is one of the most important oil seed crops in Myanmar. Sunflower is a short duration crop and can be grown twice in a year. Sunflower plants are grown commercially in many countries such as India, China, Russia, South Africa and Myanmar (Ahmad *et al*., 2009). Sunflower is primarily grown in Sagaing, Mandalay, Magway and Ayeyarwady regions as well as Shan State. The majority of oilseed sunflower currently grown in Myanmar are mahuyar, Doatkhit, Sunfola, Sinshwekyar-2 and Yezin-1 cultivars (Khin Mar Mar Nwe *et al.,* 2000). Among them, hybrid sunflower cultivar, Yezin-1 used in this experiment is the most popular in Magway Division.

EM is widely used as beneficial microbial inoculums for making bokashi and the use of EM helps to increase crop yields enhancing soil fertility, conserve the soil productivity, improve biological properties, and also physical amelioration of soil structures. Base material for the production of bokashi can be obtained easily around the farms, like straw, grasses, legumes, rice hask, manure, and sawdust (Vetayasuporn, 2006).

EM bokashi is the organic fertilizers help to purify the ecosystem and increase crop productivity (Alam and Seth, 2012). The use of microbial inoculants has been shown to increase the mineralization of organic materials (Pan *et al.,* 2012; Sharma *et al.,* 2014). Bokashi is organic materials that have been fermented with EM and made for good fertilizer. EM bokashi is inexpensive, capable of producing high quality products, high yield produces and preserving the environment (Higa and Kanal, 1998).

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Therefore, this study was aimed to evaluate the effectiveness of different levels of EM Bokashi fertilizer on the yield components and yields of *Helianthus annuus* L. cv. Yezin (sunflower) under field conditions.

Materials and Methods

Experimental site

The field experiment was conducted on hybrid sunflower cultivar, Yezin-1 from January to March, 2023 at the field of Botany Department, in the University of Magway.

Preparation of Making EM Bokashi Fertilizer

(a) Bokashi basic materials, especially the dry straws were cut into small pieces. Concentrated EM solutions were mixed with molasses and water by the ratio of 1:1:18.

(b) Firstly, spreading the small pieces of straw is stacked in layer to form a pile and the pile is sprinkled with the mixture of EM solution.

(c) Secondly, cowdung manure was made a layer on the grasses pile.

(d) The groundnut expeller cake was put onto the cow dung as a layer.

(e) Chaff ashes were spread onto the groundnut expeller cake and

(f) Put the rice bran as a layer.

This procedures are repeated until the pile was about to reach 3 feet. The pile was covered with plastic sheet to keep it air-tight. After three weeks, the compost is ready to use.

Figure 1. Preparation of Making EM Bokashi Fertilizer

Analysis of Soil Sample and Prepared EM Bokashi Fertilizer

For soil analysis, the soil from the experimental area of 6 inches depth was randomly collected from five places before sowing. The collected soil samples and the prepared EM bokashi fertilizer were analyzed at the laboratory of Land Use Department, Ministry of Agriculture, Livestock and Irrigation in Magway Division.

Experimental Design and Treatments

Field experiment was carried out by using Randomized Completely Block Design (RCBD). Each plot considered of three rows. Total of 15 plants were included in each plot. The row-to-row spacing was 60 cm and the plant-to-plant spacing was 30 cm. The size of each plot was 4 ft x 5 ft. A total of four treatments with three replications were employed. The different levels of EM bokashi fertilizer such as T_0= 0 ton acre^{-1}, T_1= 1 ton acre^{-1}, T_2= 2 tons acre^{-1} and T_3= 3 tons acre^{-1} were conducted.

Cultivation and Fertilization

For the study of field experiment, three seeds of hybrid sunflower, Yezin-1 were directly sown in each hole. After one week of sowing seeds, two plants were thinned and only one healthy plant was left in each hole. Different levels of EM bokashi fertilizer (0, 1, 2 and 3 tons acre^{-1}) were applied before one week of sowing seeds. During the experiment, weeding and watering were properly done whenever necessary.

Data Collection and Statistical analysis

Plant height, number of leaves, and single leaf area were collected at weekly interval. Head diameters, seed lengths and widths, 100 seeds weight, total seeds weight (plant^{-1}) and seed yields kg acre^{-1} and basket acre^{-1} were also collected at the harvesting time.

The data were analyzed by using IRRISTAT software programmed. All treatment means were compared by LSD (Least Significant Differences) at 5% level of significance.

Methods

Single Leaf Area

The leaf samples were collected and measured the length and width. The single leaf areas (LA) were computed as follow:

LA = K x L x W

LA = Single leaf area

K = Adjustment factor

L = Leaf length

W = Broadest width

K value varies with the shape of leaf and it is also affected by the variety, nutritional status and growth stage of the leaf. The adjustment factor, K value (0.87) for sunflower was measured according.

Yield Estimation

According to training manual of oil seed crop, yield estimation was calculated by the following formula:

$$\text{Yield (basket acre}^{-1}\text{)} = \frac{\text{Number of plants acre}^{-1} \text{x Number of seeds plant}^{-1} \text{x 1000 seed weight (g)}}{454 \text{x} 32 \text{x} 1000}$$

Results

Physical and Chemical Properties of Cultivated Soil

As a result, the type of the soil for the study was silt loam and moderate alkaline (pH 7.84). The moisture 3.195 % and organic carbon percentage were 2.154. The contents of N, P and K found in the soil were low levels such as 0.108 %, 1.041 ppm and 0.291 % respectively. K_2O was medium levels 13.636 (mg/100gm).

Physical and Chemical Properties of EM Bokashi Fertilizers

The results of the study showed that the chemical constituents of EM bokashi was composed of 2.281 % moisture contents, 24.251% organic matter, pH 7.08, 0.86 % N, 1.409 % P_2O_5 and 1.188 % K_2O, respectively.

Plant Height

In this experiment, plant height was obviously increased with times after 56 DAS. The plant height of sunflower had no significant differences in all treatments. Among treatments, the mean of tallest plant height (67.56 cm plant^{-1}) was obtained in plants growing in 3 tons acre^{-1} of EM bokashi fertilizer treatment. The shortest plant height (56.32 cm plant^{-1}) was obtained in T_0 (0 tons acre^{-1} of EM bokashi) treated plants (Table 1, Figure 2).

Table 1. Effects of different levels of EM bokashi fertilizer on plant height of *Helianthus annuus* L. cv. Yezin-1

Treatments	Plant Height (cm plant^{-1})								Means
	Growing Period (DAS)								
	7	14	21	28	35	42	49	56	
T_0 (0 ton acre^{-1})	3.76	14.84	21.44	38.99	59.99	98.66	105.44	107.44	56.32
T_1 (1 ton acre^{-1})	3.28	14.98	25.14	49.55	75.10	110.55	117.88	119.77	64.53
T_2 (2 tons acre^{-1})	3.31	16.16	20.26	52.55	77.55	116.21	123.32	125.66	66.88
T_3 (3 tons acre^{-1})	4.10	15.25	26.84	51.21	78.44	116.66	120.21	127.77	67.56
F-test	ns	ns	ns	ns	ns	ns	ns	ns	-
5% LSD	0.95	4.21	8.29	13.81	18.13	20.84	18.61	15.46	-
CV%	14.0	14.6	17.6	15.3	13.2	10.0	8.5	6.3	-

Mean differences within each column determined by LSD at 5 % level of significant. ns = non-significance, DAS= day after sowing seeds.

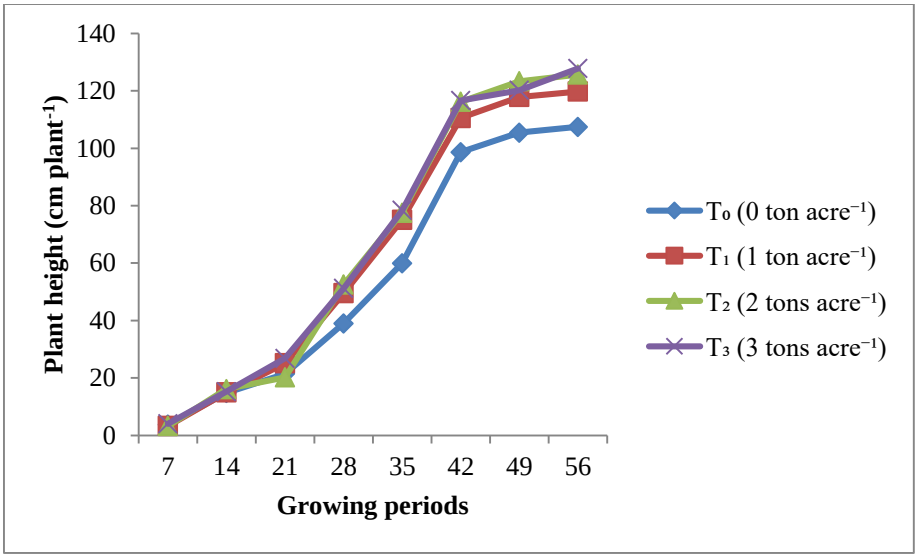

Figure 2. Effects of different levels of EM bokashi fertilizer on plant height of*Helianthus annuus* L. cv. Yezin-1

Number of Leaves

The numbers of leaves were drastically increased at 28 DAS. Statistically, the numbers of leaves were significantly differences (P≤0.05) among treatments at 7 DAS and 14 DAS. However, no significantly differences were found in all treatments after 14 DAS up to 56 DAS. The maximum mean number of leaves (22.80) was found in plants treated with 3 tons acre^{-1} of EM bokashi fertilizer compared to control, 0 ton acre^{-1} of EM bokashi fertilizer (21.40) (Table 2, Figure 3).

Table 2. Effects of different levels of EM bokashi fertilizer on number of leaves of *Helianthus annuus* L. cv. Yezin-1

Treatments	Number of Leaves plant^{-1}								Means
	Growing Period (DAS)								
	7	14	21	28	35	42	49	56	
T_0 (0 ton acre^{-1})	4.44	9.55	17.33	24.88	27.99	28.88	29.10	29.10	21.40
T_1 (1 ton acre^{-1})	5.55	9.55	17.99	25.33	28.66	29.10	29.10	29.10	21.79
T_2 (2 tons acre^{-1})	6	11.54	17.77	27.55	29.55	29.55	29.55	29.55	22.52
T_3 (3 tons acre^{-1})	5.55	10.22	19.11	25.33	28.33	30.44	30.55	30.66	22.80
F-test	*	*	ns	ns	ns	ns	ns	ns	-
5% LSD	0.91	1.38	3.13	2.66	2.67	3.40	3.67	3.81	-
CV%	8.8	8.8	9.4	5.1	6.4	7.1	7.2	7.3	-

Mean differences within each column determined by LSD at 5 % level of significant.
* =significant at 5% (P≤0.05), ns = non-significance, DAS= day after sowing seeds.

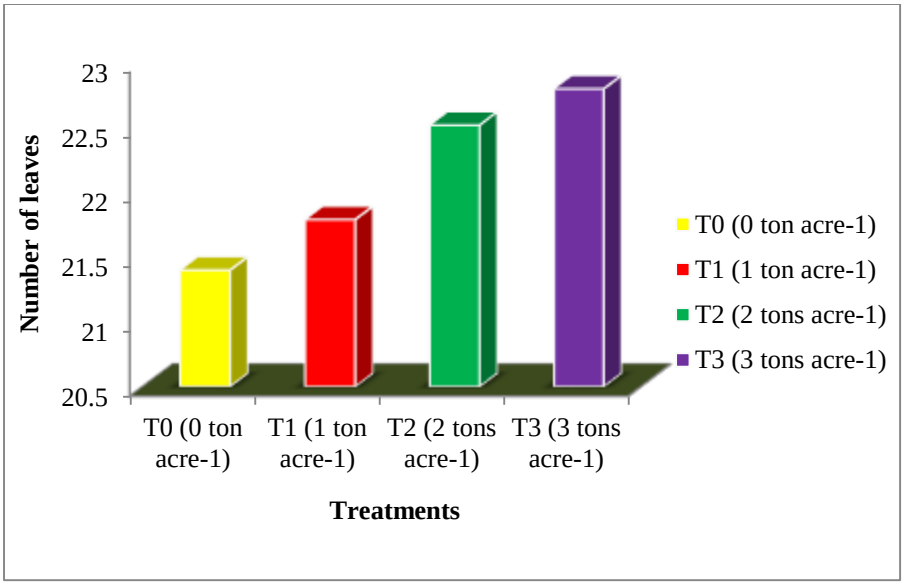

Figure 3. Effects of different levels of EM bokashi fertilizer on number of leaves of *Helianthus annuus* L. cv. Yezin-1

Single Leaf Area

The single leaf area of *Helianthus annuus* L. cv. Yezin-1 were obviously increased with times. Yezin-1 sunflower cultivar showed statistically significant differences ($P \leq 0.05$) among treatments at 7 DAS and 21 DAS. The results of mean single leaf area showed that the maximum leaf area (94.60 cm^2) was obtained in the treatment of 3 tons $acre^{-1}$ of EM bokashi fertilizer, in contrast, 0 ton $acre^{-1}$ of EM bokashi (Control) was attained in minimum leaf area (66.95 cm^2) (Table 3, Figure 4).

Table 3. Effects of different levels of EM bokashi fertilizer on single leaf areas of *Helianthus annuus* L. cv. Yezin-1

Treatments	Single Leaf Area (cm^2)					Means
	Growing Period (DAS)					
	7	14	21	28	35	
T_0 (0 ton $acre^{-1}$)	11.72	23.67	64.93	113.20	121.24	66.95
T_1 (1 ton $acre^{-1}$)	15.22	26.11	79.96	132.2	148.08	80.31
T_2 (2 tons $acre^{-1}$)	18.58	37.91	103.48	141.57	165.73	93.45
T_3 (3 tons $acre^{-1}$)	15.85	29.92	86.65	153.9	186.70	94.60
F-test	*	ns	*	ns	ns	-
5% LSD	4.7	11.5	24.23	45.02	52.68	-
CV%	16.3	20.7	15.4	17.7	18.0	-

Mean differences within each column determined by LSD at 5 % level of significant.
* = significant at 5% ($P \leq 0.05$), ns = non-significance, DAS = day after sowing seeds.

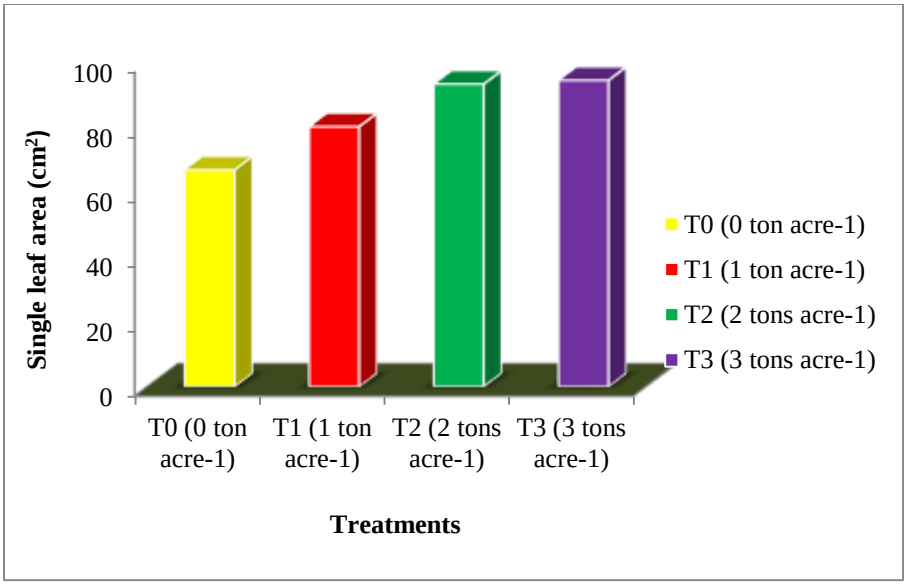

Figure 4. Effects of different levels of EM bokashi fertilizer on single leaf areas of *Helianthus annuus* L. cv. Yezin-1

Head Diameter

At harvest, the head diameters of sunflower hybrid Yezin-1 were statistically highly significant differences (P≤0.01) among all treatments. Among all treatments, the maximum head diameter (12.57 cm) was obtained in T_3, 3 tons acre^{-1} of EM bokashi fertilizer treated plants. The minimum head diameter (8.01 cm) was observed in T_0, 0 tons acre^{-1} of EM bokashi fertilizer (Table 4, Figure 5).

Table 4. Effects of different levels of EM bokashi fertilizer on head diameters of *Helianthus annuus* L. cv. Yezin-1

Treatments	Head Diameters (cm plant^{-1})
T_0 (0 ton acre^{-1})	8.01
T_1 (1 ton acre^{-1})	10.17
T_2 (2 tons acre^{-1})	10.31
T_3 (3 tons acre^{-1})	12.57
F-test	**
5% LSD	1.57
CV%	8.1

Mean differences within each column determined by LSD at 5 % level of significant.
** = significant at 1% (P≤0.01).

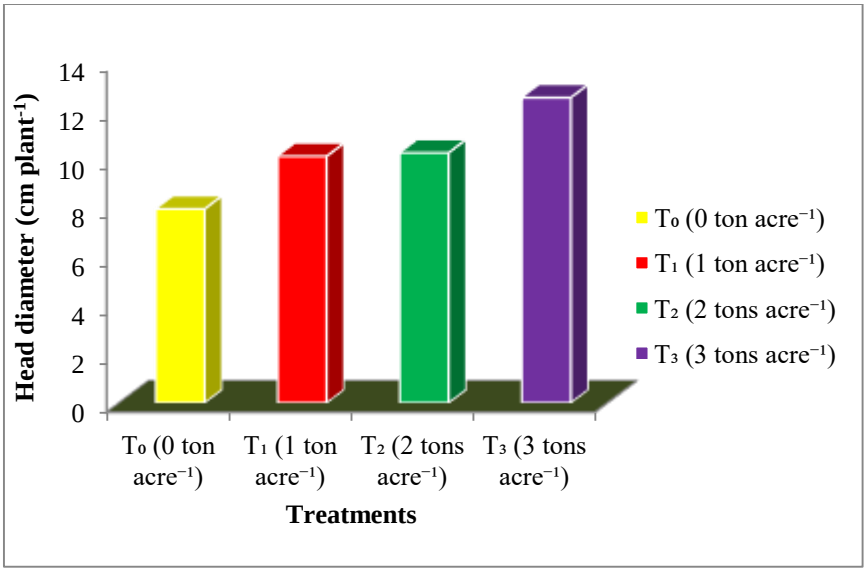

Figure 5. Effects of different levels of EM bokashi fertilizer on head diameters of *Helianthus annuus* L. cv. Yezin-1

100 Seeds Weight, Total Seeds Weight and Seed Yield

In this experiment, the 100 seed weight and total seed weight of sunflower had statistically highly significant differences (P≤0.05 and P≤0.01) at harvesting times. Among all treatments, the highest 100 seeds weight (6.73 g), and total seeds weight (46.32 g plant^{-1}) were obtained in T_3, 3 tons acre^{-1}of EM bokashi fertilizer treated plants. The lowest 100 seeds weight (3.69 g) and lowest total seeds weight (23.94 g plant^{-1}) were obtained in T_0, 0 ton acre^{-1} of EM bokashi treatments. Moreover, the maximum seed yield (1.59 tons acre^{-1} and 33.39 baskets acre^{-1}) were obtained in 3 tons acre^{-1} of EM bokashi fertilizer compared to control (0 ton acre^{-1}), which was (0.82 tons acre^{-1} and 12.32 baskets acre^{-1}) (Table 5, Figure 6).

Table 5. Effects of different levels of EM bokashi fertilizer on 100 seeds weight, totalseeds weight and seed yields of *Helianthus annuus* L. cv. Yezin-1

Treatments	100 Seeds Weight (g plant^{-1})	Total Seeds Weight (g plant^{-1})	Seed Yield (tons acre^{-1})	Yield (baskets acre^{-1})
T_0 (0 ton acre^{-1})	3.69	23.94	0.82	12.32
T_1 (1 ton acre^{-1})	4.72	33.14	1.13	18.41
T_2 (2 tons acre^{-1})	5.29	33.34	1.14	24.16
T_3 (3 tons acre^{-1})	6.73	46.32	1.59	33.39
F-test	**	*	-	-
5% LSD	0.81	11.71	-	-
CV %	8.4	18.3	-	-

Mean differences within each column determined by LSD at 5 % level of significant.
* = significant at 5% (P≤0.05), ** = significant at 1% (P≤0.01).

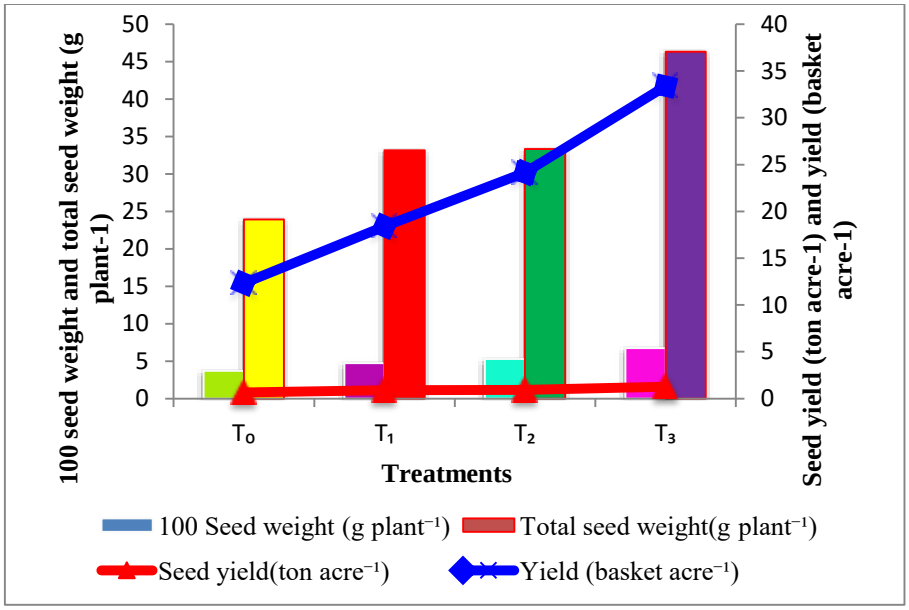

Figure 6. Effects of different levels of EM bokashi fertilizer on 100 seeds weight, total seeds weight and seed yields of *Helianthus annuus* L. cv. Yezin-1

Discussion and Conclusion

The field study were carried out to evaluate the effects of different levels of EM bokashi such as (0, 1, 2, 3 tons acre^{-1}) application on sunflower plants were provided greater yield components and yields of *Helianthus annuus* L. cv. Yezin-1.

According to the results of the study, the plant height was increased progressively over time and the tallest plant height was recorded in plants applied with 3 tons acre^{-1} of EM bokashi helped in producing taller plant with an average height of (67.56 cm). Similar results have previously been reported on upland rice by (Haslim, 2016), in which rice husk bokashi 10 tons ha^{-1} significantly increased plant height.

In this study, the effects of EM bokashi on the number of leaves per plant shown in (Table 2), the maximum mean number of leaves plant^{-1} (22.52) was obtained in 3 tons acre^{-1} of EM bokashi. Palacio-Roman and Agudelo-Esobar, (2020) mentioned that application of organic manure had significant effect on the number of leaves for sunflower.

Due to the experiment, the leaf area was significantly affected by EM bokashi fertilizer application on hybrid sunflower cultivar. The maximum leaf area (94.60 cm^2) was recorded by applying 3 tons acre^{-1} of EM bokashi fertilizer. The similar results reported by (Haslim, 2016), in which rice husk bokashi 10 tons ha^{-1} significantly increased leaf number, and total leaf length and width.

Head diameter is one of the important yield components in sunflower. Head diameters were significantly increased with EM bokashi compare with control. Among the treatments, the application of 3 tons acre^{-1} of EM bokashi was obtained in maximum head diameter (12.57 cm plant^{-1}). These results are similar to those of mentions of (Safari, 2003) who reported an increase in head diameters with increasing organic manure rates, this effect might attribute to positive contributions of nutrients release by organic fertilizer of plant growth.

One of the yield components characters, the 100 seeds weight is commonly used as a major determinant of sunflower yields. The different levels of EM bokashi treatments had significant effects on 100 seeds weight and total seeds weight of hybrid sunflower cultivar. After harvest, the maximum 100 seeds weight (6.73 g plant^{-1}), and total seeds weight (46.32 g plant^{-1}) were obtained in the plant grown in 3 tons acre^{-1} EM bokashi fertilizer in field. Klalan and Berger, (1963) also revealed that seeds weight contributes greatly to seed yields.

In order to the sunflower yields, the seed yield is mostly defined as a result of the cumulative effects of various yield components under the influence of EM bokashi fertilization. In this study, the total seeds yield was found to be (1.59 tons acre^{-1} and 33.39 baskets acre^{-1}) in the 3 tons acre^{-1} EM bokashi fertilizer treated plants. Similarly, (Moe Moe Ngwe, 2021) reported that hybrid sunflower cultivar Yezin-1 can be produced over 30 baskets per acre^{-1}. Nsaifabbas *et al*., (2014) also showed that the increase in yield was due to the efficacy of bokashi and EM as fertilizer supplementing the necessary nutrients for plant growth.

In conclusion, Making EM bokashi is also easy to produce as bio-fertilizer by farmers using with the available farm-yard raw materials. Based on results of different levels of EM bokashi fertilizer application on hybrid sunflower cultivar, Yezin-1, seed yields contributing characters such as head diameter, 100 seed weight, and total seed weight were significantly influenced by the increased levels of EM bokashi fertilizer. By studying this, the level of EM bokashi fertilizer can be optimized as 3 tons acre^{-1} for the best performances in the cultivation of high yield producing hybrid sunflower cultivar Yezin-1. Therefore, 3 tons acre^{-1} of EM bokashi fertilization should be applied for hybrid sunflower cultivar. On the other hands, using the one of the bio-fertilizers, EM bokashi fertilizer with EM technology is simple, sustainable, economically viable, beneficial for farmers' livelihoods and environmentally friendly. However, further research studies should be extended in other crops to promote the organic farming system and to produce the high yield with short life spans, and good quality of organic products in the near future.

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